Remarks

Favorable reconsideration of this application is respectfully requested. Claims 1 and 4-7 are amended. Claims 1-10 are pending. The specification and drawings are revised to address formal issues. No new matter has been added.

Drawings

The drawings are objected to for various informalities. Reconsideration of the objections is respectfully requested in view of the following.

i) Cleaner substitute figures 1-3 of the drawings are provided to replace the current figures 1-3 on file, in which figures 1-2 are merely made clearer, and figure 3 is especially amended to indicate the three coordinate axes X, Y and Z as well as the point P in addition to being made clearer.

ii) Substitute figure 12 of the drawings is provided to replace the current figure 12, in which indications are made to the two coordinate axes.

iii) "Curve 1" and "curve 2" are to be amended to "first curve" and "second curve" throughout the specification and claims, so that the reference characters "1" and "2" are only used to designate "water-cooled wide copper plates".

iv) Regarding Fig. 3, Applicants respectfully submit that the reference numbers in Fig. 3 are all mentioned in the description at page 10. With particular reference to "de", it is referred to when describing "O", which is the midpoint of the segment between d and e.

v) Substitute figures 4-11 of the drawings are provided, in which the reference signs "α" and "β" are cancelled because they are otiose. However, "α" and "β" in figures 13-20 are to be retained, with some explanations being added in the specification. For example, the corresponding passage in the specification has been amended above and is as follows:

> *"In Fig. 13, a comparison of the upper opening curves in horizontal direction between a TCC mold of the prior art and a TCC mold of the invention is shown. In the figure, α denotes the prior art, and β denotes the present invention. This also applies to Figs. 14-20. In Fig. 14, a comparison of the first derivatives of upper opening curves in horizontal direction*

between a TCC mold of the prior art and a TCC mold of the invention is shown. In Fig. 15, a comparison of the second derivatives of upper opening curves in horizontal direction between a TCC mold of the prior art and a TCC mold of the invention is shown. In Fig. 16, a comparison of the curvatures of upper opening curves in horizontal direction between a TCC mold of the prior art and a TCC mold of the invention is shown."

Based on the above, Applicants respectfully request withdrawal of the drawing objections.

Specification

The specification is objected to for informalities. Applicants respectfully submit a revised abstract and other revisions to the description, as suggested by the Examiner. Reconsideartion and withdawal of the specification objections is respectfully requested.

Claim Objections

The claims are objected to for informalities. Amended claim 1 is provided, in which reference characters that are not the factors involved in the invention are placed within parentheses, and in which grammatical errors are corrected. Reconsideartion and withdawal of the specification objections is respectfully requested.

Claim Rejections- 35 U.S.C. 112

Claims 1-10 are rejected under 35 U.S.C. 112, second paragraph for being indefinite. Applicants respsectfully request reconsideration of the rejection based on the following comments and explanations.

Claim 1 has been amended to help clarify the invention. For example, "cavity of the mold" is clarified as being defined by the inside surfaces of the two water-cooled narrow copper plates and the two water-cooled wide copper plates. This is understood by a reading of the second passage in the Detailed Description of the Invention portion of the specification with reference to Figs. 1 and 2.

In amended claim 1, "a selected one of the water-cooled wide copper plates" is aimed at, and "a three dimensional coordinate system" is positioned relative to the

selected water-cooled wide copper plate for the purpose of determining the configruation of the inside surface of the selected water-cooled wide copper plate. This is understood by a reading of the related description in the specification with reference to Fig. 3. In Fig. 3, the thee dimensional coordinate system is positioned such that the X axis lies in the planar surface portion of the inside surface of the selected water-cooled wide copper plate and parallel to the top face of the mold, the Y axis is parallel to the water-cooled narrow copper plates and the top face of the mold, and the Z axis is parallel to the central axis. Particular location of the origin of the X-Y-Z coordinate flexible as long as the coordinate is so positioned relative to the selected water-cooled wide copper plate.

It is also clarified in amended claim 1 that the upper inclined linear segment of every second curve has a ratio k of a distance from the lower endpoint of the linear segment to the planar surface portion of the inside surface of the selected water-cooled wide copper plate to a distance from the upper endpoint of the linear segment to said planar surface portion. This is understood from Fig. 22 in conjunction with Fig. 3 as well as the associated description in the specification.

In amended claim 1, correction is made that it is the curve segments of every first and second curves, rather than the entire curves (containing the linear segments at the opposite ends of the respective curve segments), meet the predefined equations. This is evident from the descriptions in the specification (for example, see the passage with reference to figures 8 and 22), which would be understood by one of skilled in the art.

In amended claim 1, the equation $f(x)=\sum_{i=0}^{n} a_i x^i$ is amended to $y=f(x)=\sum_{i=0}^{n} a_i x^i$ by adding "y=", and the equation $f(x)=\sum_{j=0}^{m} b_j z^j$ is amended to $y=f(z)=\sum_{j=0}^{m} b_j z^j$ by adding "y=" and correcting "f(x)" to "f(z)". Further, the expression "... where m has a minimum value of 5, b_j=$\underline{f_j\ (D,\ d,\ k)}$; ..." is corrected to "... where m has a minimum value of 5, b_j=$\underline{f_j\ (D,\ d,\ k,\ f(x))}$; ...". These revisions are made to correct apparent clerical errors.

Regarding claims 4-7, revisions of these claims have been made to eliminate lack of antecedent basis issues.

With further reference to claim 1, the Office Action states that claim 1 is unclear as to what particular position and location with respect to the overall water-cooled mold would be embodied by "curves 1 (first curves)" and "curves 2 (second curves)".

Applicants respectfully submit that amended claim 1 is clear regarding the configuration of the inside surface of either of the water-cooled wide copper plate of the mold, thus the configuration of the overall water-cooled mold. The present invention of claim 1 recites inside surfaces of the two water-cooled wide copper plates, each of which includes a curved surface portion, and the two water-cooled narrow copper plates, each of which is a smooth planar surface. The present invention of claim 1 recites the configuration of the curved surface portion of the inside surface of each water-cooled wide copper plate.

For example, a selected one of the water-cooled wide copper plates, the inside surface thereof is formed of a plurality of points P, each of which is an intersection point of two curves, i.e., a first curve and a second curve, that are orthogonal to each other. Once the first and second curves are determined in their shapes, the configuration of the inside surface of the selected water-cooled wide copper plate, thus of the overall configuration of the cavity of the mold, will be fixed. Furthermore, each of the first and second curves is composed of a curve segment in the middle and two linear segments at two opposite ends. The present invention of claim 1 provides equations for the curve segment of each of the first and second curves.

As can be clearly understood from the definitions in claim 1 and the description made with reference to Fig. 3, the configuration of a selected water-cooled wide copper plate can be determined by establishing a three dimensional X-Y-Z coordinate system with the X axis lying in the planar surface portion of the inside surface of the selected water-cooled wide copper plate and parallel to the top face of the mold, the Y axis parallel to the water-cooled narrow copper plates and the top face of the mold, and the Z axis parallel to the central axis of the mold. Particular location of the coordinate system is flexible, and with the established coordinate system, the curves may be determined within the system by the recited equations.

During determination of the shapes of the first and second curves, the shape of the first curve at the top face of the mold, i.e., at the top end of the selected water-cooled wide copper plate, can be determined first, and then the shapes of all the second curves can be determined starting from said determined first curve. For example, if a technician intends to design a continuous metal casting mold having a specific water-cooled wide copper plate inside surface, he or she can set the value for the factor H at the top face of the mold and the associated value for the factor k as well as the values for the factors L, D and d according to the practical demands for the product, whereby the shape of the curved surface portion (i.e., the area encircled by letters a, b, c, g, d, e and f in Fig. 3) of the inside surface of the selected water-cooled wide copper plate can be determined. Then, upon setting the values for the factors l_0 and d_0, the configuration of the entire inside surface (including the curved surface portion and the planar surface portion) of the selected water-cooled wide copper plate can be determined.

With further reference to Fig. 3, for example, the inside surface of a selected water-cooled wide copper plate relative to an established X-Y-Z coordinate system is shown, where the gridding surface represents the inside surface of the selected water-cooled wide copper plate of claim 1. The area abcgdef (i.e., $L \times D$) of the gridding surface represents the curved surface portion of the inside surface, determined by the two equations recited in claim 1, and the curved surface portion so determined is smoothly continuous with the remaining planar surface portion. With further reference to the plan view (in the plane parallel to the X-Y plane of the coordinate system, i.e., in horizontal plane) of the mold shown in Fig. 1 and the side view (in the plane parallel to the Y-Z plane, i.e., in vertical plane) of the mold shown in Fig. 2 as well as to the horizontal sections of the mold in two coordinate systems shown in Figs. 21 and 23 and the vertical section of the mold in one coordinate system shown in Fig. 22, it can be clearly seen that the factor **H** in claim 1 refers to the height from the valley point to the peak point of the curved segment of the first curve, **L** refers to the width of the curved segment of the first curve, **d** refers to the length of the curved segment (from the upper connection point m to the lower connection point n) of the second curve projected onto the Z axis, **D** refers to

the total of the projected length d of the curved segment of the second curve and the projected length of the upper inclined linear segment of the second curve, and **k** refers to the ratio of the distance from the lower endpoint of the upper inclined linear segment of the second curve to the planar surface portion of the inside surface of the selected water-cooled wide copper plate to the distance from the upper endpoint of the upper inclined linear segment of the second curve to said planar surface portion (the value for the factor **k** is dependent from the slope of the upper inclined linear segment of the second curve).

As indicated above, specific values for these factors can be set by the technician according to the practical demands in design. A combination of the selected values for these factors can determine a particular configuration of the curved surface portion of the inside surface of the selected water-cooled wide copper plate, including the position and orientation of the upper inclined linear segment of the second curve (i.e., the locations of the upper and lower endpoints of the upper inclined linear segment of the second curve within the coordinate system). In other words, once the above factors are set, the values for a_i and b_j in the equations can be easily calculated by the technician, and thus the equations can be fixed. The shapes of the curve segments of the first and second curves, thus the configuration of the curved surface portion of the inside surface of the selected water-cooled wide copper plate, are determined by particular values selected for the factors H, L, d, D and k as well as for the integrals, i and j.

As to the calculation of the values for a_i and b_j in the equations, it has been described by way of examples in the original specification and is clear to those skilled in the art.

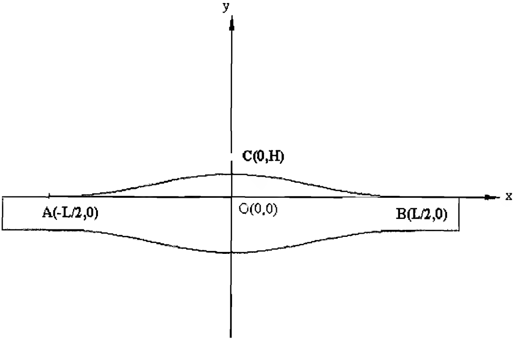
As would be understood by one of skill in the art, the mathematic expression may vary for the same curve segment as the location of the origin of the established coordinate system varies. Accordingly, those skilled in the art will understand that if the origin of the coordinate is differently located, the values for a_i and b_j in the equations for the horizontal and vertical curves may be different. In other words, if the origin of the coordinate is not located at a special or symmetric point, the expressions for the equations may differ.

This is shown in the following additional examples of calculation, of which one of skill in the art would understand.

Example 1 (horizontal curve, i.e., the first curve)

In this example, the origin O of the coordinate system is located at the projection point of the central axis on the plane in which the valley points of the horizontal curve lie. The second derivatives at the points A and B are continuous, and the first derivative at the point C is continuous.

The coordinate system is established as shown below:



Calculation method 1:

There are the following limiting conditions:

Point A: $x = -L/2$;

$y = 0$;

(1)

$$\frac{dy}{dx}=0;$$

(2)

$$\frac{d^2y}{dx^2}=0;$$

(3)

Point C: x=0;

y=H;

(4)

$$\frac{dy}{dx}=0;$$

(5)

Point B: x=L/2;

y=0;

(6)

$$\frac{dy}{dx}=0;$$

(7)

$$\frac{d^2y}{dx^2}=0.$$

(8)

Accordingly, there are totally 8 limiting conditions.

Assumming the horizontal curve is in the form of multinomial, since there are 8 limiting conditions, then there will be:

$$y=a_7x^7+a_6x^6+a_5x^5+a_4x^4+a_3x^3+a_2x^2+a_1x+a_0; \qquad (9)$$

$$\frac{dy}{dx}=7a_7x^6+6a_6x^5+5a_5x^4+4a_4x^3+3a_3x^2+2a_2x+a_1; \qquad (10)$$

$$\frac{d^2y}{dx^2}=42a_7x^5+30a_6x^4+20a_5x^3+12a_4x^2+6a_3x+2a_2. \qquad (11)$$

By substituting the limiting equations (1)-(8) in the equations (9), (10) and (11), and solving the simultaneous equations by computer, the following can be obtained:

a_0=H; a_1=0; a_2=$-\frac{12H}{L^2}$; a_3=0; a_4=$\frac{48H}{L^4}$; a_5=0; a_6=$-\frac{64H}{L^6}$; a_7=0.

Calculation method 2:

Since the curve in the above figure is symetric about the Y axis, the equation (9) should be an even function, i.e., $a_1=0;a_3=0;a_5=0;a_7=0$.

By substituting the limiting equations (1)-(4) in the equations (9), (10) and (11), and solving the simultaneous equations by computer, the following can be obtained:

$a_0=H$; $a_2=-\frac{12H}{L^2}$; $a_4=\frac{48H}{L^4}$; $a_6=-\frac{64H}{L^6}$; and thus

$$y=-\frac{64H}{L^6}x^6+\frac{48H}{L^4}x^4-\frac{12H}{L^2}x^2+H.$$

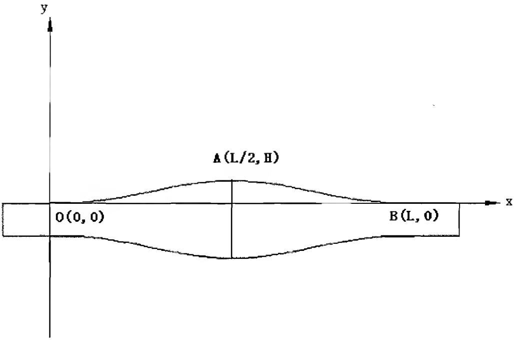
If the practical process requires H=50 mm and L=900 mm, then a_0-a_6 can be determined and the above equation will be:

$$y=-6.02\times10^{-15}x^6+3.66\times10^{-9}x^4-7.41\times10^{-4}x^2+50.$$

Example 2 (horizontal curve, i.e., the first curve)

In this example, the origin O of the coordinate system is located at the connecting point between the left horizontal linear segment and the horizontal curve. The second derivatives at the points O and B are continuous, and the first derivative at the point A is continuous.

The coordinate system is established as shown below:



There are the following limiting conditions:

Point O: x=0;

y=0;

(1)

$$\frac{dy}{dx}=0;$$

(2)

$$\frac{d^2y}{dx^2}=0;$$

(3)

Point A: x=L/2;

y=H;

(4)

$$\frac{dy}{dx}=0;$$

(5)

Point B: x=L;

y=0;

(6)

$$\frac{dy}{dx}=0;$$

(7)

$$\frac{d^2y}{dx^2}=0.$$

(8)

Accordingly, there are totally 8 limiting conditions.

Assumming the horizontal curve is in the form of multinomial, since there are 8 limiting conditions, then there will be:

$$y=a_7x^7+a_6x^6+a_5x^5+a_4x^4+a_3x^3+a_2x^2+a_1x+a_0;$$

(9)

$$\frac{dy}{dx}=7a_7x^6+6a_6x^5+5a_5x^4+4a_4x^3+3a_3x^2+2a_2x+a_1; \qquad (10)$$

$$\frac{d^2y}{dx^2}=42a_7x^5+30a_6x^4+20a_5x^3+12a_4x^2+6a_3x+2a_2. \qquad (11)$$

By substituting the limiting equations (1)-(8) in the equations (9), (10) and (11), and solving the simultaneous equations by computer, the following can be obtained:

$$a_0=0;\ a_1=0;\ a_2=0;\ a_3=\frac{64H}{L^3};\ a_4=-\frac{192H}{L^4};\ a_5=\frac{192H}{L^5};\ a_6=-\frac{64H}{L^6};\ a_7=0,$$

and thus

$$y=-\frac{64H}{L^6}x^6+\frac{192H}{L^5}x^5-\frac{192H}{L^4}x^4+\frac{64H}{L^3}x^3.$$

If the practical process requires H=50 mm and L=900 mm, then a_0-a_6 can be determined and the above equation will be:

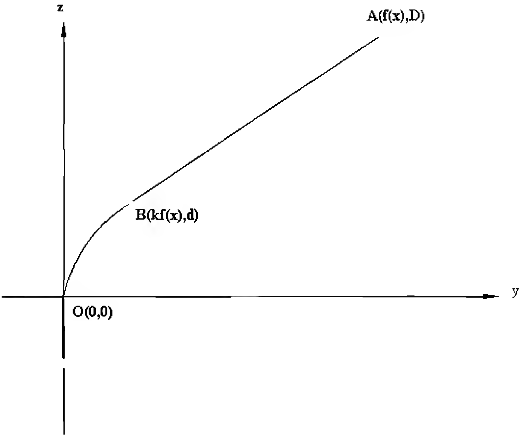
$$y=-6.02\times10^{-15}x^6+1.63\times10^{-11}x^5-1.46\times10^{-8}x^4+4.39\times10^{-6}x^3.$$

As evident from comparison with Example 1, if location of the origin of the coordinate is varied, the same curve would have a different mathematic expression and different values for a_i. If the origin of the coordinate is located at a more generic position, then the equation would vary.

Example 3 (vertical curve, i.e., the second curve)

In this example, the origin O of the coordinate system is located at the connecting point between the lower linear segment and the vertical curve. The second derivatives at the points O and B are continuous.

The coordinate system is established as shown below:



In the above figure, D is the total depth of the curved portion of the mold in the direction of the Z axis (D can be equal to 700 mm), and d is the depth of the vertical curve in the direction of the Z axis. Assumption is made that the height of the upper endpoint of the upper inclined linear segment in the direction of the Y axis is f(x) and lower endpoint of the upper inclined linear segment in the direction of the Y axis is kf(x) (i.e., the curve involved is at the x value) (k can be set to 0.12, and f(x) can be 50 mm).

From the geometry:

$$\frac{z-z_1}{z_2-z_1}=\frac{y-y_1}{y_2-y_1}. \quad (1)$$

By substituting the coordinate values of the points A and B:

$$\frac{z-D}{d-D}=\frac{y-f(x)}{kf(x)-f(x)}. \quad (2)$$

Accordingly, the equation of the linear segment will be:

$$y=\frac{D-z}{D-d}(k-1)f(x)+f(x), \quad (3)$$

$$\frac{dy}{dz}=\frac{1-k}{D-d}f(x) \quad (4)$$

There are the following limiting conditions for the curve equations:

Point B: z=d;

$$y=kf(x); \quad (5)$$

$$\frac{dy}{dz}=\frac{1-k}{D-d}f(x);$$

(6)

$$\frac{d^2y}{dz^2}=0;$$

(7)

Point O: z=0;

$$y=0;$$

(8)

$$\frac{dy}{dz}=0;$$

(9)

$$\frac{d^2y}{dz^2}=0.$$

(10)

Accordingly, there are totally 6 limiting conditions.

Assumming the vertical curve is in the form of multinomial, since there are 6 limiting conditions, then there will be:

$$y=b_5z^5+b_4z^4+b_3z^3+b_2z^2+b_1z+b_0, \quad (11)$$

$$\frac{dy}{dz}=5b_5z^4+4b_4z^3+3b_3z^2+2b_2z+b_1, \quad (12)$$

$$\frac{d^2y}{dz^2} = 20b_5z^3 + 12b_4z^2 + 6b_3z + 2b_2 . \qquad (13)$$

By substituting the limiting equations (5)-(10) in the equations (11), (12) and (13), and solving the simultaneous equations by computer, the following can be obtained:

$b_0=0$; $b_1=0$; $b_2=0$;

$$b_3 = 2\frac{5Dk-3dk-2d}{(D-d)d^3}f(x);$$

$$b_4 = -\frac{15Dk-8dk-7d}{(D-d)d^4}f(x);$$

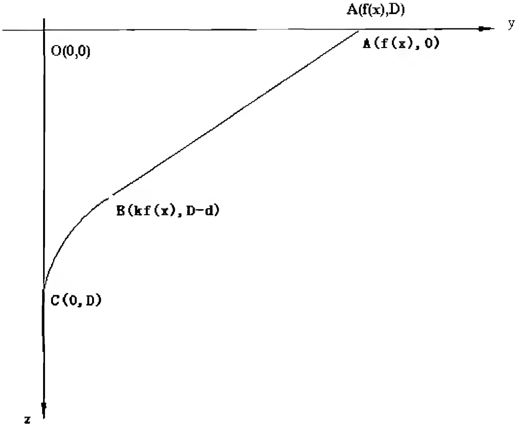
$$b_5 = 3\frac{2Dk-dk-d}{(D-d)d^5}f(x).$$

Since D, d, k and f(x) are known and constant, b_0-b_5 can be determined.

Example 4 (vertical curve, i.e., the second curve)

In this example, the origin O of the coordinate system is located at the projection point of the upper endpoint of the upper inclined linear segment on the extension line of the lower vertical linear segment. The second derivatives at the points B and C are continuous.

The coordinate system is established as shown below:



In the above figure, D is the total depth of the curved portion of the mold in the direction of the Z axis (D can be equal to 700 mm), and d is the depth of the vertical curve in the direction of the Z axis. Assumption is made that the height of the upper endpoint of the upper inclined linear segment in the direction of the Y axis is f(x) and lower endpoint of the upper inclined linear segment in the direction of the Y axis is kf(x) (k can be set to 0.12, and f(x) can be 50 mm).

From the geometry:

$$\frac{z-z_1}{z_2-z_1}=\frac{y-y_1}{y_2-y_1}. \qquad (1)$$

By substituting the coordinate values of the points A and B:

$$\frac{z-0}{D-d}=\frac{y-f(x)}{kf(x)-f(x)} \qquad (2)$$

Accordingly, the equation of the linear segment will be:

$$y = \frac{(k-1)f(x)}{D-d} z + f(x), \quad (3)$$

$$\frac{dy}{dz} = \frac{k-1}{D-d} f(x) \quad (4)$$

There are the following limiting conditions for the curve equations:

Point B: z=D-d;

y=kf(x);

(5)

$$\frac{dy}{dz} = \frac{k-1}{D-d} f(x);$$

(6)

$$\frac{d^2y}{dz^2} = 0;$$

(7)

Point C: z=D;

y=0;

(8)

$$\frac{dy}{dz} = 0;$$

(9)

$$\frac{d^2y}{dz^2} = 0.$$

(10)

Accordingly, there are totally 6 limiting conditions.

Assumming the vertical curve is in the form of multinomial, since there are 6 limiting conditions, then there will be:

$$y = b_5 z^5 + b_4 z^4 + b_3 z^3 + b_2 z^2 + b_1 z + b_0,$$

(11)

$$\frac{dy}{dz} = 5b_5 z^4 + 4b_4 z^3 + 3b_3 z^2 + 2b_2 z + b_1, \quad (12)$$

$$\frac{d^2y}{dz^2} = 20b_5 z^3 + 12b_4 z^2 + 6b_3 z + 2b_2. \quad (13)$$

By substituting the limiting equations (5)-(10) in the equations (11), (12) and (13), and solving the simultaneous equations by computer, the following can be obtained:

$$b0 = \frac{(6D^2k - 12Ddk - 3Dd + 4d^2 + 6d^2k)D^3}{d^5} f(x),$$

$$b1 = -2D^2 \frac{(62Dd^2k + 28Dd^2 - 75dD^2k - 18d^3k - 12d^3 - 15D^2d + 30D^3k)}{d^5(D-d)} f(x),$$

$$b2 = 6D \frac{(10D^2k - 10Ddk - 5Dd + 2d^2 + 3d^2k)}{d^5} f(x),$$

$$b3 = -2 \frac{(21Dd^2k + 14Dd^2 - 45dD^2k - 3d^3k - 2d^3 - 15D^2d + 30D^3k)}{d^5(D-d)} f(x),$$

$$b4 = \frac{(-30Ddk - 15Dd + 30D^2k + 8d^2k + 7d^2)}{d^5(D-d)} f(x),$$

$$b5 = -3 \frac{(-dk - d + 2Dk)}{d^5(D-d)} f(x).$$

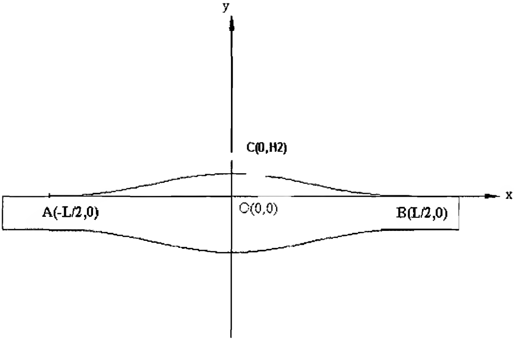
Since D, d, k and f(x) are known and constant, b_0-b_5 can be determined.

As evident from comparison with Example 3, if location of the origin of the coordinate is varied, the curve will have a different mathematic expression and different values for b_j. If the origin of the coordinate is located at a more generic position, then the equation would vary.

Example 5 (horizontal curve, i.e., the first curve)

The horizontal curve is in a horizontal section at any level z in the range of the upper inclined linear segment of the vertical curve. In this example, the origin O of the coordinate system is located at the projection point of the central axis on the plane in which the valley points of the horizontal curve lie. The second derivatives at the points A and B are continuous, and the first derivative at the point C is continuous.

The coordinate system is established as shown below:



There are the following limiting conditions:

Point A: $x = -L/2$;

$y = 0$;

(1)

$$\frac{dy}{dx} = 0;$$

(2)

$$\frac{d^2y}{dx^2} = 0;$$

(3)

Point C: $x = 0$;

$y = H_2$;

(4)

$$\frac{dy}{dx} = 0;$$

(5)

Point B: $x = L/2$;

$$y=0;$$

(6)

$$\frac{dy}{dx}=0;$$

(7)

$$\frac{d^2y}{dx^2}=0.$$

(8)

Accordingly, there are totally 8 limiting conditions.

Assumming the horizontal curve is in the form of multinomial, since there are 8 limiting conditions, then there will be:

$$y=a_7x^7+a_6x^6+a_5x^5+a_4x^4+a_3x^3+a_2x^2+a_1x+a_0;$$

(9)

$$\frac{dy}{dx}=7a_7x^6+6a_6x^5+5a_5x^4+4a_4x^3+3a_3x^2+2a_2x+a_1; \qquad (10)$$

$$\frac{d^2y}{dx^2}=42a_7x^5+30a_6x^4+20a_5x^3+12a_4x^2+6a_3x+2a_2. \qquad (11)$$

By substituting the limiting equations (1)-(8) in the equations (9), (10) and (11), and solving the simultaneous equations by computer, the following can be obtained:

$$a_0=H_2;\ a_1=0;\ a2=-\frac{12H_2}{L^2};\ a_3=0;\ a_4=\frac{48H_2}{L^4};\ a_5=0;\ a_6=-\frac{64H_2}{L^6};\ a_7=0.$$

H_2 is the maximum height of the horizontal curve in a horizontal section at any level z in the range of the upper inclined linear segment of the vertical curve, and its value can be secured according to the coordinate system of Example 3:

$$H_2=\frac{D-z}{D-d}(k-1)H+H$$

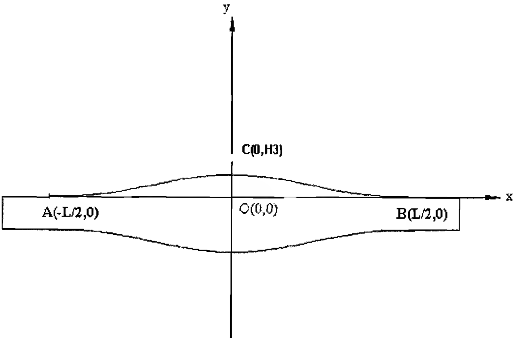
Since H, L, D, d and k are set constant, and z is known as the level of the horizontal section, a_0, a_1, a_2, a_3, a_4, a_5, a_6 and a_7 will become constants.

Example 6 (horizontal curve, i.e., the first curve)

The horizontal curve is in a horizontal section at any level z in the range of the curve segment of the vertical curve. In this example, the origin O of the coordinate

system is located at the projection point of the central axis on the plane in which the valley points of the horizontal curve lie. The second derivatives at the points A and B are continuous, and the first derivative at the point C is continuous.

The coordinate system is established as shown below:



There are the following limiting conditions:

Point A: $x=-L/2$;

$y=0$;

(1)

$$\frac{dy}{dx}=0;$$

(2)

$$\frac{d^2y}{dx^2}=0;$$

(3)

Point C: $x=0$;

y=H_3;

(4)

$$\frac{dy}{dx}=0;$$

(5)

Point B: x=L/2;

y=0;

(6)

$$\frac{dy}{dx}=0;$$

(7)

$$\frac{d^2y}{dx^2}=0.$$

(8)

Accordingly, there are totally 8 limiting conditions.

Assumming the horizontal curve is in the form of multinomial, since there are 8 limiting conditions, then there will be:

$$y=a_7x^7+a_6x^6+a_5x^5+a_4x^4+a_3x^3+a_2x^2+a_1x+a_0; \qquad (9)$$

$$\frac{dy}{dx}=7a_7x^6+6a_6x^5+5a_5x^4+4a_4x^3+3a_3x^2+2a_2x+a_1; \qquad (10)$$

$$\frac{d^2y}{dx^2}=42a_7x^5+30a_6x^4+20a_5x^3+12a_4x^2+6a_3x+2a_2. \qquad (11)$$

By substituting the limiting equations (1)-(8) in the equations (9), (10) and (11), and solving the simultaneous equations by computer, the following can be obtained:

$a_0=H_3$; $a_1=0$; a2$=-\frac{12H_3}{L^2}$; $a_3=0$; $a_4=\frac{48H_3}{L^4}$; $a_5=0$; $a_6=-\frac{64H_3}{L^6}$; $a_7=0$.

H_3 is the maximum height of the horizontal curve in a horizontal section at any level z in the range of the curve segment of the vertical curve, and its value can be secured according to the coordinate system of Example 3:

$$H_3=b_5z^5+b_4z^4+b_3z^3+b_2z^2+b_1z+b_0 \qquad (12)$$

wherein

$b_0=0$; $b_1=0$; $b_2=0$;

$$b_3 = 2\frac{5Dk-3dk-2d}{(D-d)d^3}H$$
$$b_4 = -\frac{15Dk-8dk-7d}{(D-d)d^4}H$$
$$b_5 = 3\frac{2Dk-dk-d}{(D-d)d^5}H$$

Since H, L, D, d and k are set constant, and z is known as the level of the horizontal section, a_0, a_1, a_2, a_3, a_4, a_5, a_6 and a_7 will become constants.

Claim Rejections – 35 U.S.C. 102/103

Claims 1-8 are rejected under 35 U.S.C. 102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as being obvious over Arvedi et al. (US 6390177). Claims 9 and 10 are also rejected under 35 U.S.C. 103(a) as being obvious over Arvedi et al. (US 6390177). Applicants respectfully request reconsideration of the rejections.

The present invention of claim 1 provides a novel curve equation, by means of which a curve segment is determined allowing the opposite endpoints of the curve segment to be smoothly connected to respective two linear segments (i.e., at least the second derivatives at the endpoints are continuous). According to claim 1, such a curve segment is applied to all the horizontal sections (i.e., the first curves) and the vertical sections (i.e., the second curves) of the inside surfaces of the water-cooled wide copper plates so as to obtain completely smooth inside surfaces forming the cavity of the mold. The inside surfaces provided by the present invention of claim 1 can produce a slab with good surface quality, reduce uneven wear of the mold and result in an extended lifecycle of the mold. The present invention, as claimed in amended claim 1, is not disclosed or suggested in Arvedi et al.

Furthermore, as discussed above with respect to the clarity of amended claim 1, claim 1 now clearly defines the configuration of either of the two water-cooled wide copper plates, thus of the overall water-cooled mold. Accordingly, amended claim 1 clearly distinguishes the present invention from Arvedi et al. For at least the foregoing reasons, claim 1 is patenable over Arvedi et al.

Favorable reconsideration and withdrawal of the rejections are respectfully requested.

In view of the above amendments and remarks, Applicants believe that this application is in a condition for allowance. A Notice of Allowance is respectfully solicited. If any questions arise regarding this communication, the Examiner is invited to contact Applicants' representative listed below.

Respectfully submitted,

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